REMARKS

Reconsideration of this patent application is respectfully requested in view of the foregoing amendments, and the following remarks.

This will make of record a telephone interview with Patent Examiner Behrend on December 13, 2002, during which this patent application was discussed.

The amendments to this patent application are as follows. In the drawings, it is proposed to add new FIGS. 7 and 8 to show the different control elements for a boiling water reactor (BWR) and a pressure water reactor (PWR).

The Specification has been amended on Pages 10, 11, 12, 13, 16 and 26 in order to over come to various formal objections by the Patent Examiner.

The claims were amended as follows. Claim 2 was canceled. Claim 1 was amended to recite that each absorber rod is moveable within the control element. Claim 5 has been amended to delete the term "preset."

In response to the formal objection of claims 1 to 9 under

35 U.S.C. 112, the Applicant comments as follows.

Enclosed is a copy of *Kerntechnik Vol. 57 Number 2* as cited in the present Specification on Page 9. On Page 84 of *Kerntechnik* there is a description of the control assemblies of pressurized water reactors. On Page 84 FIG. 1 shows a control assembly and at the bottom a control rod.

On page 102 of *Kerntechnik* there is a description of a control rod for boiling water reactors.

On Page 2 of the Official Action, there was an objection to the alleged lack of "materials." On Page 18 in paragraph 2 of the present Specification, it is stated "the absorber enclosures 7 have a sheet metal jacket, which assures mechanical integrity." In "*Kerntechnik*" page 85 it says in a first paragraph: "Each rod comprises, an absorber, which is enclosed gas-tight in a stabilized austenitic steel cladding tube with welded end plugs." It is the normal state of the art to produce this rods and absorber enclosures from steel.

Regarding the objection to "wall thickness," on Page 26 of the present Specification it is described in detail that the

absorber enclosures can have a wall thickness of 0.1 mm and have a space of about 0.01 mm. It should be clear, that in the spacings is "nothing" or air. The spacing can be calculated from AE of the tubes as also explained in FIG. 5 and the corresponding description.

Concerning the objection to Specification Page 10 it has to be noted that this is a special embodiment. The absorber enclosure could be removed by guiding it in a controlled way to the outside. In the further description on Specification page 11, line 7 is given a description for such a controlled way. In such a case the absorber enclosure could be made from semicircles. However, this language has been canceled. The objections of the Patent Examiner on page 3 also concern an embodiment with half shells. This language has been canceled.

Concerning the objection on the bottom of page 3 of the Office Action concerning claim 1 the description on page 10 clearly states that the term removable is to be understood in such a way that the absorber enclosure loses its directly limiting function in which it exerts pressure inwardly. Thus the absorber enclosure breaks up or get destroyed in some other way.

There was an objection to the term "wherein" in various

claims. However, this term is understood by those skilled in the art. This is an art recognized term, since it appears in several claims of the *Dietrich* U.S. Patent cited by the Patent Examiner. It is also found in claims of the *Kurihara* U.S. Patent cited by the Patent Examiner.

Regarding the objection to "removable", the present Specification on Page 10 describes the invention with a number of absorber enclosures nested into each other or in an alternative form with movable half shelves. The objected to paragraph language has been canceled.

Regarding the Specification on page 11, the objected to language, in the paragraph on page 11, has been deleted.

On Page 3 of the Official Action, there was an objection to the term "limiting device." In response thereto, the last paragraph on page 12 of the Specification and first paragraph on page 13 of the Specification relates to an embodiment, which has been deleted.

There was an objection to the term "part segments. In response thereto, the absorber enclosures or the absorber tubes are long hollow tubes. To make the handling easier it is

not one tube, but it is made from a number of tubes or part segments, which are placed one after another. This is state of the art. In the present invention, there are three absorber enclosures nested into each other. It should be avoided that the abutting surfaces of adjacent absorber enclosures are disposed directly next to each other. It is better to arrange them in such a way that the abutting surfaces of the outer absorber enclosures are for example displaced by half of the lengths of such a part segment compared to the abutting surfaces of the part segments of the middle absorber enclosures. These part segments have to be understood in a longitudinal direction and are therefore abutting. The outer, middle, and inner absorber enclosures are spaced from each other seen in a vertical direction to the longitudinal direction of the control elements.

On Page 4 of the Official Action, there was an objection to Claim 5. Sintered absorber tablets are in common use in control elements. Claim 5 relates to adopting the inner absorber enclosure to the dimensions of such sintered absorber tablets. The word "preset" has been deleted so as to overcome this objection.

Concerning the objections to Claims 8 and 9, the control element is a component of the BWR or of the PWR, and not vise-versa.

Concerning the disclosure of BWR and PWR the enclosed journal *Kerntechnik* provides a sufficient description thereof.

On Page 16 of the Specification, the reference to FIG. 3a has been canceled. On Page 16 of the Specification, new FIGS.7 and 8 are listed.

On Page 5 of the Official Action, the Drawings were objected to. In claim 1 the term a respective absorber enclosure is removable from a starting position and a mechanical resistance is formed for compressing and containing the absorber is defined on page 10 of the present Specification. This can been seen from newly added FIGS. 7 and 8.

Claim 2 concerns an embodiment which has been deleted. The invention as now claimed contains absorber enclosures which always completely surround the inner enclosures as recited in claim 3. The embodiment according to claim 3 is shown in FIG. 3,7 and 8.

Concerning claims 8 and 9 the drawings of the enclosed document *Kerntechnik* have been used, since it was incorporated by reference. Claims 8 and 9 refer to a control element adapted to fit in a boiling water reactor, or into a pressurized water reactor. Page 26 of the Specification refer to new FIGS. 7 and 8.

Objected to terminology on Pages 10, 11, 12, 13 and 16 of the Specification has been canceled.

For all these reasons, it is firmly believed that the drawings, the Specification, and the claims are now in complete compliance with the requirements of 35 U.S.C. 112. Withdrawal of this ground of rejection is respectfully requested.

Concerning the prior art rejection, claim 1 has been amended to recite features concerning the control element, for a nuclear reactor, in particular, that the absorber rod is movable within the control element, to further differentiate the claimed invention from the prior art cited by the Examiner which does not refer to such absorber rods.

Dietrich describes several cylinders, whereby in FIG. 4 the "cylinder" 328 is the absorber and the "cylinder" 329 is the "fuel element." This is completely different from an absorber material surrounded by three absorber enclosures, as recited by the claims of the present invention.

Kaufmann discloses absorber elements 102, which can be positioned in several positions according to FIGS. 6, 7 and 8,

whereby the relevant position and distribution of the absorber material 102 can be changed. This is also completely different from the absorber material being enclosed within three absorber enclosures, as recited by the claims of the present invention.

Benzler describes absorber tubes 5, 6 with holes 7, 8, whereby the tubes can be changed in their position so that the holes within the absorber material can be changed in their size and thereby the effect of the absorber can be changed. In FIG. 4 there is in the middle a moderator 9 not an absorber. In FIG. 5 there is a further absorber on the outside.

Williams document discloses a nuclear reactor fuel element assembly. The burnable fuel elements 16 (compare FIG. 3) have in the middle a burnable poison 20. This poison or absorber has an influence on the burning conditions <u>but is not movable within the arrangement for control functions</u>. This is an old technology. Today the uranium cf the fuel elements itself is mixed with $Gd_2\ 0_3$ as absorber. The burnable poison rod 20 is located within a tube 21 and a further sleeve 26 within an undefined spacing of strip material and a further strip 23. Thus five fuel rods are accommodated and are working as a fuel element with an integrated burnable absorber.

In *Kurihara* the control rods of this device are formed as tubular rods 33 (see FIG. 5) and are movable hydraulically into and out of the reactor core. The tubular absorber rods 33 are slidable within a fill element 36 (for example graphite working as a moderator). This is completely different from absorber material surrounded by three absorber enclosures.

McCorkle describes fuel assemblies 61a (FIG. 11 and 9 consisting of three tubular fuel tube bundles 86 and an assembly working as a burnable absorber rod (poison rod 93) surrounded by a berrylium cylinder (91). Such fuel assemblies are not working as control rods (compare explanations to Williams). The control elements of this reactor are formed by the control rods 118 as shown in Fig. 13, 14, 15 consisting of cadmium cylinders 118a raised and lowered into the fuel assemblies 61a (see Fig. 9) by means of control shafts 121 (see Fig. 13, 14).

In summary, claims 1 and 5 have been amended; claim 2 has been canceled; and claims 1, and 3 to 9 are pending. In view of these amendments, the claims are not anticipated under 35 U.S.C. 102, but are patentable under 35 U.S.C. 103. A prompt notification of allowability is respectfully requested.

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Enclosures: 1)Marked up Copy Amended Claims and Specifications
2)Copy Petition Three Month Extension of Time
3)Proposed New Drawing FIGS. 7 and 8
4)Copy *Kerntechnik*

I hereby certify that this correspondence is being deposited with the U.S. Postal Service as first class mail in an envelope addressed to: Assistant Commissioner of Patents, Washington, D.C. 20231, on March 12, 2003.

Maria Guastella

MARKED-UP VERSION

AMENDED CLAIMS AND SPECIFICATION

1. (Amended) A control element for a nuclear reactor comprising:

a plurality of absorber rods (7) each absorber rod (7) comprising at least an inner absorber enclosure (10), an outer absorber enclosure (13) and a first middle absorber enclosure (11), wherein the absorber enclosures are fitted and nested into each other and concentric in their relationship;

a predetermined spacing between each of the absorber enclosures surrounding and adjacent to one another; and

each absorber rod movable within the control element;

an absorber (8) contained only within the inner absorber enclosure (10);

wherein, in the event of expansion of the absorber, a respective absorber enclosure is removable from a starting position and a mechanical resistance is formed for compressing and containing the absorber.

5. (Amended) The control element according to claim 1, wherein dimensions of the inner absorber enclosure are selected in such a way that the inner absorber enclosure receives [preset] absorber tablets.

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longer capable of withstanding the swelling absorber, the absorber enclosure yields when a certain expansion is reached. The absorber enclosure may then be removable from the starting position in that it breaks or gets destroyed~~, or by guiding it in a controlled way to the outside, where it continues to form a mechanical resistance for the absorber,~~ The term "removable", therefore, is to be understood to mean that the absorber enclosure is either actually spatially removed from its starting or initial position or loses its directly limiting function in which it exerts pressure inwardly. Thus the absorber enclosure breaks up or gets destroyed in some other way, whereas residual parts, however, remain physically in the initial position. The control element so created may be subjected to burn up a_m of almost 100% without burnt-off absorber material getting into the reactor coolant.

In another embodiment of the present invention, provision is made for at least three absorber enclosures, and whereby provision is made, furthermore, for a predetermined spacing between the absorber enclosures surrounding and embracing one another. Upon expansion of the absorber, the respective absorber enclosure is removable from its initial position and mechanical resistance is provided for the absorber.

The outer absorber enclosure then forms a solid outer jacket, whereas the inner absorber enclosure initially abuts the absorber and offers resistance to the swelling absorber. However, the inner absorber enclosure breaks apart at a defined pressure, so that the absorber can continue to expand in the direction of the outer absorber enclosure. ~~The inner absorber enclosure may also form, for example a semicircle adjacent to the outer absorber enclosure.~~

In a further embodiment of the present invention, provision is made for three or more absorber enclosures surrounding and adjacent to one another because it is possible in this way to offer the swelling absorber several resistances in a staggered and easily presettable manner. These resistances will yield one after the other and in this way will permit a particular operating duration of the control element, during which the absorber material can be completely burned up. A predetermined spacing is provided for in this embodiment between the absorber enclosures adjacent to one another. Thus the absorber enclosure disposed in the innermost position at a given time can break or be destroyed in some other way without damaging in this process the adjacent next outer absorber enclosure.

The predetermined spacing is determined depending on the effective creep deformation ε up to breakage of the material employed. Thus the absorber enclosure is first still capable of expanding within the predetermined spacing under the pressure of the absorber material before breakage of the absorber enclosure can occur.

It is a particularly preferred embodiment of the invention that the absorber enclosures are designed in such a way that the outer absorber enclosure completely envelops and surrounds the inner absorber enclosure. Therefore, this system has a plurality of absorber enclosures which are fitted or nested into each other, which initially offer resistance pressure to the absorber expanding from the inside outwardly. These enclosures are preferably concentric and then yield to the expansion pressure and break. Thus the absorber enclosure disposed next to the further swelling absorber establishes mechanical pressure compressing the absorber and effectively prevents uncontrolled swelling expansion of the absorber.

~~In another embodiment of the invention, the limiting~~ device is made of an elastic and heat-resistant material, which is attached from the ~~inside~~ to the outer absorber enclosure. Such a material would first ~~apply~~ pressure inwardly to the expanding absorber, but then yield to the

~~increasing pressure of the absorber, forcing it outwardly.~~ In a further embodiment, the absorber enclosure has mechanical mobility, so that it comprises, for example movable half shells. These half shells are pressed against the absorber by a mechanical element, for example by springs or other elastic intermediate elements, and removed under the pressure of the absorber from the ~~starting position and pressed outwardly.~~

In a preferred embodiment of the invention, the dimensions of the inner absorber enclosure are selected in such a way that the inner absorber enclosure is suitable for receiving preset sintered absorber tablets. Also, it is possible to employ a powder as the absorber. B_4C is preferably used as the absorber. B_4C shows an excellent neutron-absorbing cross-section, in particular for thermal neutrons. However, like all known absorbers, it exhibits strong neutron-induced expansion which, in the long term, leads to destruction of the absorber enclosure. Another absorber which can be employed is, for example Ag In Cd, or a material containing boron which is enriched with the isotope B-10.

It is particularly preferred to employ B_4C with less than 70% of a theoretic density, particularly of less than 60% because swelling of the absorber can be initially prevented in this way, and a particularly high burn up

In the drawings, wherein similar reference characters denote similar elements throughout the several views:

FIG. 1a shows a 99% theoretical density pellet irradiated to≈3,5% ^{10}B burn-up at 865° F (80X) disclosed in the prior art;

FIG. 1b is a schematic representation of a nuclear cell in a boiling water reactor;

FIG. 2 is a top view of a control element;

FIG. 3 is a cross section through an absorber enclosure of a control element of the invention;

FIG. 3a shows a perspective view of the absorber rod;,

FIG. 4 is a graph showing the "critical", local burn up distribution of a standard control element at the start of washout;

FIG. 5 is a graph schematically showing the burn up percentage a_m and the local burn-up distribution $a(r)$ of a control element according to the invention; and

FIG. 6 is a graph explaining the achievable burn up.

FIG. 7 shows

FIG. 8 shows

follows from the line denoted by 31. The use of lower theoretical densities results in a higher burn up percentage a_m, which follows from the curves denoted by 32 and 33. For example, with 50% of a theoretical density (curve 33), a burn up a_m of more than 80% is achieved already with the third absorber enclosure (position 36). A burn up a_m of 90% is obtained already with the fourth absorber enclosure, which corresponds with an accumulated neutron fluence of 8.3×10^{21} n/cm² as follows from the position denoted by 37. The individual absorber enclosures have a wall thickness of 0.1 mm. A space of about 0.01 mm remains between the absorber enclosures. If the latter are designed with different wall thicknesses, for example the inner three absorber enclosures each with a wall thickness of 0.1 mm and a fourth outer absorber enclosure with a wall thickness of 0.5 mm, this would be more favorable overall than having a wall thickness of 0.5 mm for the innermost absorber enclosure and a wall thickness of 0.1 mm for each of the three outer absorber enclosures.

21 The design of the control elements according to the invention, (FIGS. 7 and 8) can be computed with the help of the microscopic burn up theory, and which has been verified also by different measurements. This shows that the pressure load acting on the control elements is basically determined by the B_4C expansion due to swelling. The

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